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SPECIAL THEORY OF RELATIVITY IS ALSO FAILED TO EXPLAIN NULL RESULT OF MICHELSON AND MORLEY EXPERIMENT

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ABSTRACT

Michelson and Morley conducted an experiment in the year 1887 to measure the speed of earth in luminiferous aether. In this experiment Michelson's interferometer was used in which two waves are superimposed to generate interference fringes. Keeping in view known velocity of earth around the sun a fringe shift of 0.44 fringe was expected on the rotation of interferometer at an angle of 90^0, but surprisingly no fringe shift was observed. The experiment was conducted so many times and at so many places but always null results were obtained. The null result of MMX could not be explained by classical mechanics. A number of explanations for null results were submitted but no one was found to be correct. George Fitzerald and Hendrick Lorentz proposed length contraction hypothesis in the direction of motion of earth, but it was also rejected being an adhoc hypothesis. Albert Einstein submitted his famous theory "The special theory of relativity" in the year 1905. The second postulate of the STR states that speed of light is constant in all directions of inertial frames of reference irrespective of motion of source of light or the observer and states that no luminiferous aether exist as a medium, light waves do not require any medium to propagate. As light travels with constant velocity in both the arms of interferometer irrespective of motion of interferometer and there involves no time difference between the two rays hence null results of MMX were explained by special theory of relativity.

Michelson and Morley experiment is based on the wave nature of light. In such experiments wavefront of light plays very important role but behaviour of wavefront of light was not taken into consideration while deriving the time taken by the light rays in the arms of interferometer due to motion of earth resulting into wrong derivation of time. The present article describes the principle and realization of role of wavefront of light in MMX. The time taken by light rays in the arms of the interferometer due to motion of earth depends upon the behaviour of wavefront of light. It has been established by results of Fizeau experiment and steller aberration of light that speed of light is not effected by velocity of moving medium. The derivation of time has been worked out keeping in view constancy of speed of light, wavefront of light and laws of reflection of light according to Huygen's principle.

Contrary to earlier beliefs the Lorentz length contraction hypothesis is not able to explain the null results of MMX. In the light of new facts it is established that there is no difference between theorectical results derived by classical mechanics and special theory of relativity. Special theory of relativity is also failed to explain the null result of MMX.

The null result of Michelson and Morley experiment has again become a perplexing question for physicists.

KEYWORDS: Interferometer, Interference, Fringe Shift, Wavefront, Rays of Light, Classical Mechanics, Special Theory of Relativity

INTRODUCTION

Michelson and Morley conducted an experiment to measure the velocity of earth in luminiferous aether. An interferometer was devised by Michelson in which a ray of light is splitted into two parts by a glass plate semi-silvered at the back side and the rays are sent in two directions perpendicular to each other and are reflected back by the mirrors situated at equal distance from the glass plate and are reunited at the plate to generate interference fringes. The interferometer is adjusted in such a way that one arm is pointed in the direction of motion of earth, thereafter the interferometer is rotated at 90^0 angle so that pathways of the light rays gets interchanged and change in the interference pattern due to motion of earth is observed. No expected fringe shift was observed in the interference pattern and the experiment was failed. Failure of Michelson and Morley experiment could not be explained by classical Mechanics which led to the development of special theory of relativity. In the present article analysis has been made in a very different way and it is described that special theory of relativity is also failed to explain the null results of Michelson and Morley experiment.

EXPERIMENT

In Michelson and Morley experiment plane wavefront of light is made to fall upon the glass plate and the wavefront is splitted into two parts, both the parts of wavefront travelling at right angles to each other are reflected back by two mirrors placed at equal distance from the beam splitter and are reunited at one point and interference fringes are observed. The interferometer is adjusted with one arm pointing in the direction of motion of

earth and the other perpendicular to it. While calculating the time taken by the ray of light the role of wavefront was not considered resulting into wrong derivation of time taken by light waves traversing different paths. Let us discuss the correct time taken by two beams. As shown in figure I below a parallel wavefront of light is made to fall upon the glass plate P thinly silvered at the back side. The wavefront strikes the plate at point O. The wave going towards mirror M_1 takes time t_1 to reach the mirror but by this time t_1 mirror M_1 has also moved along the motion of earth with velocity v hence the length covered by light wave will be $L+vt_1$, where L is the distance of mirror M_1 from plate P and light has travelled with velocity c in time t_1 covering the distance ct_1.

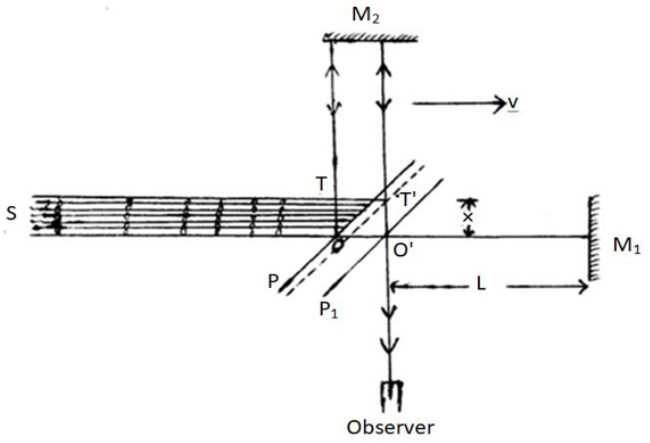

Fig - I

therefore $ct_1 = L + vt_1$

$ct_1 - vt_1 = L$

$t_1 (c - v) = L$

$$t_1 = \frac{L}{c - v}$$

for inward journey from mirror M_1 to P, let the time taken by light be t_2 , but by the time t_2 plate itself has moved towards coming light by factor vt_2 hence light wave has travelled the distance $L-vt_2$, light wave travelled the distance ct_2 with velocity c

therefore $ct_2 = L - vt_2$

$ct_2 + vt_2 = L$

$t_2 (c + v) = L$

$$t_2 = \frac{L}{c + v}$$

The total time taken by light wave from P to M_1 and M_1 to P with velocity c will be $t_1 + t_2$

therefore $t = t_1 + t_2$

$$t = \frac{L}{c-v} + \frac{L}{c+v} = \frac{Lc+Lv+Lc-Lv}{(c-v)(c+v)}$$

$$= \frac{2Lc}{C^2-V^2} = \frac{2L}{C}\frac{1}{1-\frac{V^2}{C^2}}$$

$$t = \frac{2L}{c}\frac{1}{1-\frac{v^2}{c^2}} \quad \text{..... I}$$

The wavefront reflected from glass plate P (inclined at 45^0) towards mirror M_2 will get reflected according to Huygen's principle and will go perpendicularly. In previous all works calculations were made by considering automatic cross stream path of light which is not correct. Cross stream path can only be considered when the moving earth is dragging to the light in its direction of motion. Light wavefront will go independently irrespective of the motion of apparatus or earth. By the time wavefront returns to the glass plate P the plate has moved to the new position P_1 moving with velocity v as shown in figure I. All parts of a wavefront vibrates in phase hence the another part of the same wavefront will reach at the plate on the point o' where transmitted wavefront reaches.

Let O be the point where the wavefront OT strikes at plate P. The upper part of plane wavefront is at point T. Let T' be the point where the upper part of wave front OT strikes at the plate P after time t_1. Let O' be the point where the reflected part of wave front striking at T' will reach after reflection from mirror M_2.

Let the total time taken by the wavefront traversing path TT' M_2O' be t hence OO' = vt where v is the velocity of interferometer. The upper part of wave front OT is striking the plate P at T' after time t_1, therefore TT' = ct_1 where c is velocity of light

as OO' = TT' so $ct_1 = vt$

and $$t_1 = \frac{vt}{c} \quad \text{..... (i)}$$

The distance O'T' is somewhat less than OO' by factor vt_1, because by the time wavefront T reaches T' the interferometer moved towards mirror M_1 in this time t_1 Therefore the distance O'T' = x = vt – vt_1 as (OO' = vt). Thus the distance travelled by the wavefront from. T T'M_2O' is calculate as under

$$TT'M_2O' = T\,T' + T'\,M_2 + M_2O' = vt + (L - x) + L$$

total time $$t = \frac{vt}{c} + \frac{L-X}{c} + \frac{L}{c}$$

$$= \frac{vt}{c} + \frac{L-(vt-vt_1)}{c} + \frac{L}{c} \quad \text{(because } x = vt - vt_1\text{)}$$

$$= \frac{vt}{c} + \frac{L}{c} - \frac{vt}{c} + \frac{vt_1}{c} + \frac{L}{c}$$

$$= \frac{2L}{c} + \frac{vt_1}{c}$$

$= \frac{2L}{C} + \frac{v}{C}\left(\frac{vt}{c}\right)$ (putting the value of t_1 from equation –i)

$= \frac{2L}{C} + \frac{v^2 t}{C^2}$

$t - \frac{v^2 t}{C^2} = \frac{2L}{C}$

$t\left(1 - \frac{v^2}{C^2}\right) = \frac{2L}{C}$

$$t = \frac{2L}{C}\ \frac{1}{1-\frac{v^2}{C^2}} \quad \ldots\ldots\ldots \text{II}$$

As per equation No I and II both the parts of same wave front OT will reach at the point O' by taking equal time after reflection from mirror M_1 and M_2 and no path difference is involved due to motion of earth towards mirror M_1. Both the rays of light will arrive in phase.

Let us consider the case when earth is moving in opposite direction as shown in figure II below

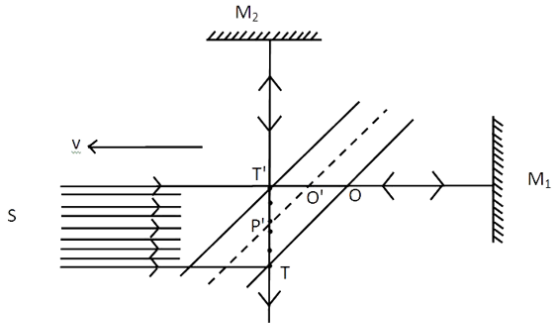

Fig II

The parallel wave front of light TT' strikes at the plate P at point T. Let the distance TT' = T' O= vt + vt_1 where v is the velocity of earth. By the time t_1 light travels from T' to O' with velocity c. hence T'O' = c t_1, in this time t_1 plate P has moved from O to O' hence OO'=vt_1. Time taken by light to complete its journey from O' to mirror M_1 and back to reach at T' be t and in this time t plate has moved the distance O'T'= vt

therefore O'T' = $ct_1 = vt$

$ct_1 = vt$

$t_1 = \frac{vt}{c}$ …… (i)

The wavefront at T will also move towards mirror M_2 in time t_1 and reaches at point P' hence TP' = ct_1 = vt and P'T' = vt_1. The distance travelled by light from P' to mirror M_2 and Back from M_2 to T' where light wave going towards mirror M_1 reaches will be P'T' + T'M_2 + M_2T' Therefore time t to complete this distance by wavefront will be as under.

$t = \frac{P'T'}{C} + \frac{T'M_2}{C} + \frac{M_2T'}{C}$

$= \frac{vt_1}{c} + \frac{L}{C} + \frac{L}{C}$

$= \frac{v}{c}\frac{(vt)}{C} + \frac{2L}{C}$ (by putting the value of t_1 from equation-i)

$= \frac{v^2}{c^2}\ t + \frac{2L}{c}$

$t - \frac{v^2}{c^2}\ t = \frac{2L}{c}$

$t\left(1 - \frac{v^2}{c^2}\right) = \frac{2L}{c}$

$$t = \frac{2L}{c}\ \frac{1}{1-\frac{v^2}{c^2}}$$

As discussed above both the waves of light going towards mirrors M_1 and M_2 perpendicular to each other takes equal time and no path difference is involved. In this case also both the rays of light will arrive in phase.

Let us consider the case when the interferometer is rotated at 90^0 angle and direction of motion of earth becomes perpendicular to the arm of interferometer towards mirror M_1 as shown in Figure III

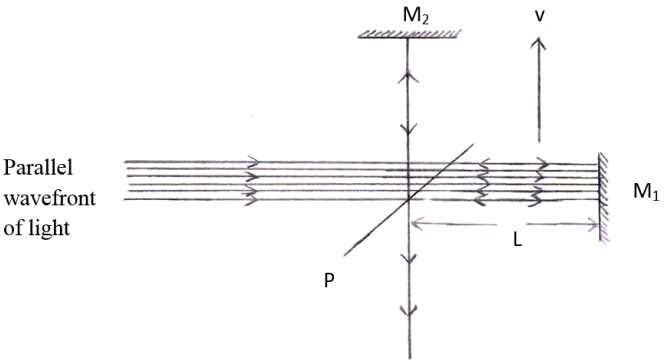

Figure III

In this case ray of light going towards mirror M_2 will be in the direction of motion of earth and time t_1 taken by this ray from glass plate to mirror M_2 and back will be $t_1 = \frac{2L}{c}\ \frac{1}{1-\frac{v^2}{c^2}}$ (already discussed)

The other ray of light going towards mirror M_1 will go in straight line and there will be no effect of motion of earth. Whole of the wavefront will reach at the mirror M_1 by travelling distance L and will return at the glass plate by travelling same distance, another part of same wavefront will reach at the glass plate therefore time t_2 taken by this ray of light will be $t_2 = \frac{2L}{c}$

The difference of time taken between both the rays of light will be as under

$$\Delta t = t_1 - t_2 = \frac{2L}{C}\frac{1}{1-\frac{v^2}{c^2}} - \frac{2L}{C}$$

$$= \frac{2L}{C}\left(1+\frac{V^2}{C^2}\right) - \frac{2L}{C} \text{ (by applying binomial theorem)}$$

$$= \frac{2L}{C} + \frac{2L\,V^2}{C^3} - \frac{2L}{C}$$

$$= \frac{2L\,V^2}{C^3}$$

To find the path difference it is multiplied by the velocity of light c,

Therefore path difference $= \frac{2L\,V^2}{C^3} \times c \qquad = \frac{2L\,V^2}{C^2}$

expected fringe shift $= \frac{2L\,V^2}{\lambda C^2}$

Where L = 11 meter

v = $3 \times 10^4 m/sec.$ (velocity of earth)

c = $3 \times 10^8 m/sec.$ (velocity of light)

ʎ = wave length of light (500 nano meters)

= 500×10^{-9} meter

Fringe shift = $\frac{2\times11\times(3\times10^4)^2}{500\times10^{-9}\times(3\times10^8)^2} = \frac{22}{50} = 0.44$ fringe

As per classical mechanics fringe shift of 0.44 fringe should have been observed

Let us try to explain the null result of Michelson and Morley experiment by taking into consideration the length Contraction in the direction of motion of earth as proposed by George Fitzerald and Hendrik Lorentz.

APPLICATION OF LORENTZ LENGTH CONTRACTION HYPOTHESIS

1. When the interferometer is aligned in the direction of motion of earth towards mirror M_1. The time t_1 taken by ray of light going towards mirror M_1 and back to the glass plate P will be a under

$$t_1 = \frac{2L}{c}\frac{1}{1-\frac{v^2}{c^2}} \text{ (already discussed)}$$

The time t_2 taken by the ray of light going towards mirror M_2 and back to the plate P will be as under.

$$t_2 = \frac{2L}{c}\frac{1}{1-\frac{v^2}{c^2}} \text{ (already discussed)}$$

As per Lorentz length contraction hypothesis the length L of interferometer in the direction of motion of earth gets contracted by factor $\sqrt{1-\frac{V^2}{C^2}}$

Therefore time t_1 of light ray going towards mirror M_1 will be as under by putting the value of contracted length

$$t_1 = \frac{2L\sqrt{1-\frac{V^2}{C^2}}}{C\left(1-\frac{V^2}{C^2}\right)}$$

$$t_1 = \frac{2L}{C}\frac{1}{\sqrt{1-\frac{V^2}{C^2}}}$$

The difference of time between the two rays of light will be

$$\Delta t = t_2 - t_1 = \frac{2L}{C}\frac{1}{1-\frac{V^2}{C^2}} - \frac{2L}{C}\frac{1}{\sqrt{1-\frac{V^2}{C^2}}}$$

$$= \frac{2L}{C}\left(1+\frac{V^2}{C^2}\right) - \frac{2L}{C}\left(1+\frac{V^2}{2C^2}\right) \text{ (Applying binomial theorem)}$$

$$= \frac{2L}{C} + \frac{2LV^2}{C^3} - \frac{2L}{C} - \frac{LV^2}{C^3}$$

$$= \frac{LV^2}{C^3} \text{ ……..(i)}$$

2. When interferometer is rotated at 90^0 angle the arm of interferometer towards mirror M_1 will be in the perpendicular direction to the direction of motion of earth and arm towards mirror M_2 will be in the direction of motion of earth. The time t_1 taken by ray of light going towards mirror M_1 will be $t_1 = \frac{2L}{C}$ (Already discussed) time t_2 taken by ray of light going towards mirror M_2 is $t_2 = \frac{2L}{C}\frac{1}{1-\frac{V^2}{C^2}}$

As per Lorentz length contraction hypothesis the length L of the interferometer towards mirror M_2 in the direction of motion of earth gets contracted by Lorentz factor. Therefore time t_2 taken by ray of light going towards mirror M_2 will be as under

$$t_2 = \frac{2L\sqrt{1-\frac{V^2}{C^2}}}{C\left(1-\frac{V^2}{C^2}\right)} = \frac{2L}{C}\frac{1}{\sqrt{1-\frac{V^2}{C^2}}}$$

The difference of time between the two rays of light will be as under.

$$\Delta t = t_2 - t_1 = \frac{2L}{C}\frac{1}{\sqrt{1-\frac{V^2}{C^2}}} - \frac{2L}{C}$$

$$= \frac{2L}{C}\left(1+\frac{V^2}{2C^2}\right) - \frac{2L}{C} \text{ (by applying binomial theorem)}$$

$$= \frac{2L}{C} + \frac{LV^2}{C^3} - \frac{2L}{C}$$

$= \frac{LV^2}{C^3}$ .....(ii)

As per equation No (i) and (ii) difference of time between both the rays of light comes out to be the same on rotation of interferometer at 90^0 angle. But in the direction of motion of earth towards 45^0 angle the time taken by both the rays will become equal, hence on the rotation at 45^0 angle a fringe shift of 0.22 fringe should have been observed. As per above facts it is obvious that Lorentz length contraction hypothesis is not able to explain null results of MMX which was believed to be a solution of this problem at that time

APPLYING SPECIAL THEORY OF RELATIVITY

Let us try to apply the special theory of relativity. As per second postulate of the theory the speed of light is constant in all directions of intertial frames of reference, irrespective of motion of source of light or observer.

1. When earth is moving towards mirror M_2 with velocity v, the velocity of light is constant hence the time taken by ray of light for out ward journey will be $\frac{L}{C}$ instead of $\frac{L}{C-V}$ and time taken by ray of light for inward journey will also be $\frac{L}{C}$ instead of $\frac{L}{C+V}$ Therefore the total time taken by ray of light will be $\frac{2L}{C}$ instead of $\frac{\frac{2l}{c}}{1-\frac{V^2}{c^2}}$. The time taken by ray of light going towards mirror M_1 will be $\frac{2L}{C}$ as shown in Figure III. As whole of the wavefront will be going straight towards mirror M_1 and will return in a straight line by completing the same path as light is not effected by direction of motion of earth and it will follow the laws of reflection, hence another part of same wavefront will be able to reunite the ray coming from mirror M_2. Both the rays of light will arrive in same phase.

2. When earth is moving towards mirror M_1 with velocity v. The velocity of light is constant, hence time taken by ray of light for outward journey will be $\frac{L}{C}$ instead of $\frac{L}{C-V}$ similarly time for in ward journey will also be $\frac{L}{C}$ instead of $\frac{L}{C+V}$ The total time taken by the ray going towards mirror M_1 will be $\frac{2L}{C}$ The time taken by the ray of light of same wavefront going towards mirror M_2 travelling with constant velocity c will be $\frac{\frac{2l}{c}}{1-\frac{V^2}{c^2}}$. instead of $\frac{2L}{C}$ (as shown in figure I and II). Here situation is different, both the rays of light are not taking equal time. The difference of time between the two rays will be as under.

$$\Delta t = \frac{2L}{C}\frac{1}{1-\frac{V^2}{C^2}} - \frac{2L}{C}$$

$= \frac{2L}{C}\left(1+\frac{V^2}{C^2}\right) - \frac{2L}{C}$ (by applying binomial theorem)

$= \frac{2L}{C} + \frac{2LV^2}{C^3} - \frac{2L}{C}$

$= \frac{2LV^2}{C^3}$

According to special theory of relativity when the constant speed of light in all directions is considered in the Michelson and Morley experiment than difference in time between the two rays of light in the direction of motion of earth towards mirror M_1 comes out to be $\frac{2LV^2}{C^3}$ which is same as derived by classical mechanics and fringe shift of 0.44 fringe should have been observed on the rotation of interferometer as per special theory of relativity also.

CONCLUSION

The result of Fizeau experiment and null result of Michelson and Morley experiment led to the development of special theory of relativity. These experiments are conducted on the wave nature of light and wavefront of light plays very important role which was completely ignored earlier. Light travels with constant velocity and requires no medium to travel and the speed of light is not effected by the motion of source of light.There is no difference between a stationary medium of light and no medium of light. In both the cases behaviour of light will be the same. When an observer changes his position with reference to source of light before reaching of light up to the observer than light will have to travel a longer distance as compared to the observer at rest with reference to source of light.

There is no difference between theoretical results of MMX according to classical mechanics and special theory of relativity. As per classical mechanics as well as special theory of relativity a fringe shift of 0.44 fringe should have been observed on the rotation of interferometer at 90^0 angle. As per Lorentz length contraction hypothesis a fringe shift of 0.22 fringe should have been observed in the direction of motion of earth at 45^0 angle. If the speed of solar system is considered than ten times fringe shift should have been observed.

It reveals that special theory of relativity is also failed to explain the null result of Michelson and Morley experiment.

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